The
PSYCHOLOGICAL RECORD

Vol. I AUGUST, 1937 No. 15

THE "DELTA INDEX" OF THE ELECTRENCEPHALOGRAM IN RELATION TO INSULIN TREATMENTS OF SCHIZOPHRENIA

HUDSON HOAGLAND, D. EWEN CAMERON, MORTON A. RUBIN

This work has been aided in part by a grant from the Rockefeller Foundation.

The Principia Press, Inc.
Bloomington, Ind.

Price of this number, 20 cents

THE "DELTA INDEX" OF THE ELECTRENCEPHALOGRAM IN RELATION TO INSULIN TREATMENTS OF SCHIZOPHRENIA*

HUDSON HOAGLAND, D. EWEN CAMERON, MORTON A. RUBIN

The Clark University Biological Laboratories
and the
Research Service, Worcester State Hospital

Hoagland, Rubin and Cameron[1] have described changes in the electrencephalogram and in blood sugar following the administration of coma-producing doses of insulin followed by restorative injections of sugar in schizophrenic patients. The behavior of alpha waves (10 per second waves, Berger rhythm) as a function of blood sugar, was found to be entirely consistent with the view (Hoagland[2]) that alpha frequencies, other things being equal, are proportional to the respiration of the cortical cells producing the rhythm.

Our electrencephalograms have been recorded on paper tape with a resistance-coupled amplifier and ink-writing undulator. Lead pellets 2 to 3 mm. in diameter cemented to the scalp with collodion, making contact through a salt paste were used as leads. The grid lead was placed over the occiput 2 cm. above the inion, and the ground electrode was attached as a parallel lead behind each ear. Our tape speed was 27 mm. per sec., our amplification, 10 microvolts = 1.5 mm., and our "time constant" (time for a rectangular pulse to drop to half value) was 0.2 secs. All of these conditions are important to bring out the phenomena to be described later.

Slow, irregular waves, usually of a fifth to a half of a second in duration, have been encountered by a number of workers in conditions of impaired consciousness. Walter[3] has referred to them as delta waves and has also found them associated locally with brain tumors. In our insulin experiments, as coma is approached, there is a marked increase in the number of long waves paralleling the fall in blood sugar. The long waves disappear on the administration of glucose. In 31 untreated schizophrenics we observed a tendency for some patients to show rather more delta waves than do normals.

In our first paper a new measure of waves longer than alpha waves was described and called the "disintegration factor" since it paralleled the broken-up appearance of the base line. To avoid psychiatric

* Manuscript recommended by Dr. J. R. Kantor, August 16, 1937.

implications we now prefer to call this measure the "delta index", abbreviated D.I. To determine the D.I., a typical meter length of record is measured and a pencil line is drawn through the central portion of all waves *equal to or shorter than* alpha waves within the meter sample. For *all* waves of distinctly *longer* duration than the alphas, the line is drawn over contours of crests and troughs. The length of this curving line is then measured with a map measurer and the difference in cm. between the length of the curved line, as read from the map measurer, and 100 cm. is defined as the delta index.

The D.I. (in cm. per cent) not only changes more or less reciprocally with blood sugar during insulinization and recovery but, in 30 out of 35 insulin experiments, the post-sugar value was found to be less than the pre-insulin value. In about this same proportion of cases our patients showed at least transient improvement after treatment.[1]

Mean D.I.'s for 37 normal persons were found to be 2.1 cm., extremes 0.5 — 11.0 cm. Thirty-four of these were 3.2 cm. or less; the 3 higher values were 5.0, 6.0, and 11.0 cm. One normal person awake gave a value of 0.5 cm.; asleep, 10.9 cm. Twelve chronic alcoholics gave a mean of 2.5, extremes 0.5 — 6.0 cm. Nine manic depressives gave a mean at 2.8, extremes 1.0 to 5.2. Thirty-one untreated schizophrenics gave a mean of 6.6 cm., extremes 0.5 to 25.2. Twelve of these 31 schizophrenic values were greater than the schizophrenic mean of 6.6 cm. Despite differences in mean values (2.1 for normals, 6.6 for schizophrenics) the delta index cannot be regarded by itself as a sign of the schizophrenic state owing to overlaps in values between the groups of normals and patients. The value of the index, as will be shown, lies in its relative changes *in a given patient*.

Meter-to-meter samples of records usually vary in D.I. by not more than 1 cm. Drowsiness and movement augment the index. These factors are largely eliminated by completing the record within ten minutes of the subject's lying down, and by discarding parts of the tape where movement is seen to occur. Sample records taken from hour to hour during a day on the same subject usually exhibit agreement to within one cm. Of course, D.I.'s to be comparable must be taken with constant speed, amplification and time constant, although correction factors, to be described elsewhere, can be applied. The index is sufficiently sensitive so as to yield several cm. difference in records which to the eye look essentially alike. We regard changes of the order of 1 cm. as significant.

Eighty-four D.I.'s taken on 7 patients showing pre-treatment indices of 5 cm. or higher, each over some weeks of treatment, exhibited, in 88 per cent of the cases, complete correspondence with *independently* determined, fluctuating, objective clinical symptoms. The index increased when the patient became psychiatrically worse and decreased when he improved. With 2 other patients indices corresponded to symptoms in 60 per cent and in 70 per cent of the instances. These 2 patients were verbally unresponsive and showed comparatively little detectable day-to-day change in symptoms to correlate with the indices. Patients who have "low" pre-treatment D.I.'s (i. e., 4.0 cm. or less) about 50 per cent of our group of 31 patients, cannot, of course, be analysed by this method. In schizophrenic patients, we have found no characteristic brain waves qualitatively different from those observed in normal persons.

Table I shows data from 2 patients typical of the 7 who showed 88 per cent correspondence between psychiatric report and index. The patients were undergoing insulin treatments 5 days per week but records were made only on the dates indicated and prior to the treatment given the same day. Comments such as better, worse, etc., are comparative with respect to the patient's condition at the time of the previously tabulated date. One of us, H.H. or M.A.R. recorded the electrencephalogram, seeing the patient only each few days at the time of recording, D.E.C. made daily psychiatric diagnoses, and H.H. determined the D.I. Usually D.I.'s were checked against clinical reports only at intervals of every three or four weeks. In the case of the patient, C.A. (Table I) electrical brain wave records were taken by M.A.R. and analysed by H.H. who had not seen the patient and knew nothing of his condition. Comparison with the clinical reports of D.E.C. was made only at the termination of this series.

TABLE I

Correspondence between delta indices and progress of the psychosis.

Patient: A. S.

Date	D. I. (cm.)	Clinical comment
Nov. 27	15.0	From 27th at first steady improvement.
Dec. 3	12.0	Less excitement, better attending and social orientation.
11	5.5	Less excitement, better attending and social orientation.
23	3.6	Steady improvement.
31	3.1	Steady improvement.
Jan. 6	2.2	Steady improvement.
15	3.1	Steady improvement.
21	12.3	Spontaneous relapse, worse.
29	3.0	Again improving.

Feb. 3	4.0	Better, and gaining weight.
10	12.0	Definitely worse.

Patient: C. A.

Date	D. I. (cm.)	Clinical comment
Jan. 22	9.5	Slightly worse 22d to 27.
28	12.0	Unchanged; more irritable and unpleasant than before treatments.
Feb. 4	12.0	
9	10.8	Unchanged.
19	6.8	Much improved.
24	2.0	Continued improvement.
Mar. 1		Taken off treatment.

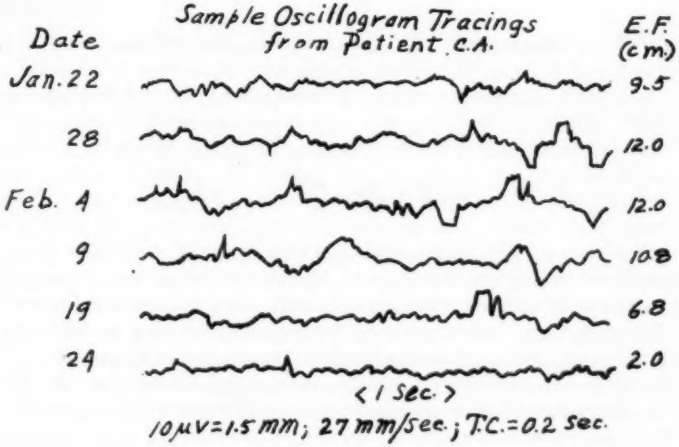

FIG. 1

Fig. 1 shows sample oscillograms of C.A. taken on the dates shown in the table. The clinical reports were based on daily interviews with the patients by D.E.C. aided by opinions of the research service ward nurses and by reports from the occupational therapy department. It may be seen from Table I that there is excellent correspondence between the D.I. values and the clinical report. On 4 occasions, with 3 of the 7 patients, the D.I. either increased or decreased significantly prior to respective relapses or improvements noted in the psychiatric report (e.g., C.A., Feb. 9, A.S., Jan. 15 and Feb. 3).

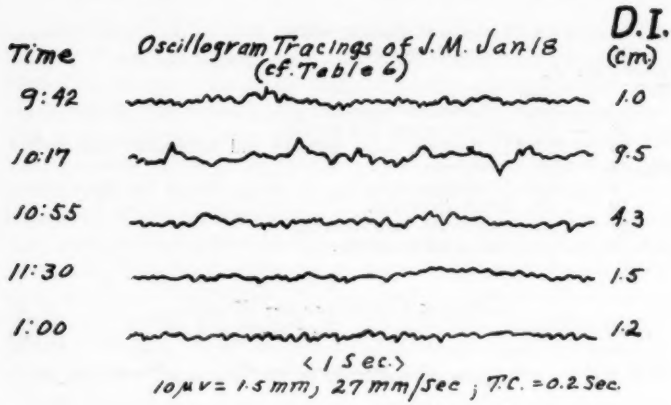

FIG. 2

One patient, J.M., not included in our group of 9 patients mentioned above, has proved of great interest. Released, after insulin treatments, in October, 1936 in apparently full remission from severe schizophrenia, he has returned to the hospital from time to time for examination. Since release he has had some 5 "spontaneous", transient set-backs, each one of which was presaged by increases in his D.I., sometimes 24-48 hours in advance of other observable symptoms. These increases in his normal index from 1.0 cm. to values of the order of 5.0, 10.0, or 20.0 cm. were always reduced following insulin treatments and his symptoms at the same time abated. In the case of this ambulant outpatient we have come to regard shifts in D.I. as highly prognostic. Aside from these 5 prognostic changes, our index in 9 other tests with J. M., which include all of his records, agreed entirely with his psychiatric condition at the date of recording.

On Jan. 18 J.M. came to the hospital for a series of hour-to-hour control tests. He had been symptom-free for a week. His first D.I. at 9:42 was 1.0 cm. To our surprise at 10:17 his D.I. was 9.5 cm. although he seemed entirely normal, merely asking us rather pointedly about his record at 10:17, a question we evaded so as not to alarm him. We later learned that he had separated 2 quarreling patients while waiting on the ward for his second test. Immediately after-

wards, he said, he experienced a resurgence of symptoms. He believed he could not return home, that he had never been an out-patient, and that his thoughts were being read by others. These compulsive, delusional ideas abated during the next hour. Fig. 2 shows sample oscillograms and corresponding indices at the times indicated. Values at roughly ¾ hr. intervals after 1:00 o'clock were 1.2, 1.2, 1.0, 0.8 cm.

Our clinical results summarized above will be dealt with at length in a psychiatric journal. In another paper (Am. J. Physiol., in press) the behavior of alpha waves and D.I. during hypoglycemia and recovery, and the standardization of the D.I. will be described in more detail.

Various workers who have examined the electrencephalogram in schizophrenic patients do not report a preponderance of long waves as contrasted to records from normal persons. Very superficially this might appear to be an objection to our work with the D.I. Such criticisms, however, are clearly irrelevant since we agree that one cannot separate patients and normals into groups by way of differences in their electrencephalograms. A single record on an individual is not at all diagnostic with respect to schizophrenia. Our schizophrenic group averages in D.I. about 4 cm. higher than our normal group. Unless indices are actually measured, and other workers have not measured them, no comparisons are significant, since to the eye, unpracticed in these measurements, differences of the order of 2 or 3 cm. are usually qualitatively indistinguishable in the appearance of the tape. It is not surprising that our small mean difference between the groups should fail to be noticed by qualitative methods of analysis.

Elsewhere (Am. J. Physiol., in press) it will be shown that differences in tape speed, amplification, time constant, and electrode size very markedly affect the measured D.I. These determinants vary in different laboratories and hence would render inappropriate comparisons of D.I.'s even if they had been measured from records taken under non-standardized conditions. In our later clinical paper* we shall show oscillograms made on several of our patients by visiting workers with an entirely independent amplifier and undulator. These records were obtained under our standard conditions and simultaneously with oscillograms taken by our own apparatus from the same pair of electrodes on the same patients. The two synchronized tapes show virtually superimposable oscillogams, and D.I.'s ranging with different patients from 1 to 12 cm. These indices were identical

* In Press, Am. J. Psychiatry, 1937.

for the two recording systems within the experimental errors common to either system alone.

For reasons stated above we believe we have eliminated movement and drowsiness artifacts. It should be noted, however, that even if we grant these factors an appreciable role, that this is no way invalidates our clinical correspondence between some hundred entirely empirical D.I. values and the fluctuating day-to-day condition of the individual patients.

We have found the empirical delta index of value as a quantitative physiological guide to changes in condition of those individual schizophrenic patients who show an appreciable number of the longer brain waves.

CITATIONS

1. H. Hoagland, Morton A. Rubin, D. E. Cameron, Electrical brain waves in schizophrenics during insulin treatments. J. of Psychol., 3: 513-519, 1936.
2. H. Hoagland, Pacemakers of human brain waves in normals and in general paretics. Am. J. Physiol., 116: 604-613, 1936.
3. W. G. Walter, Lancet, The location of cerebral tumors by electro-encephalography. 231: 305-308, 1936.